U.S. Army
Research Institute of
Environmental Medicine

Natick, Massachusetts

TECHNICAL REPORT NO. T17-06
DATE February 2017

TRADESPACE ASSESSMENT: THERMAL STRAIN MODELING COMPARISON OF MULTIPLE CLOTHING CONFIGURATIONS BASED ON DIFFERENT ENVIRONMENTAL CONDITIONS

United States Army
Medical Research & Materiel Command

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February 2017

U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*
15-02-2017

2. REPORT TYPE
Technical Report

3. DATES COVERED *(From - To)*
2015 - 2016

4. TITLE AND SUBTITLE
TRADESPACE ASSESSMENT: THERMAL STRAIN MODELING COMPARISON OF MULTIPLE CLOTHING CONFIGURATIONS BASED ON DIFFERENT ENVIRONMENTAL CONDITIONS

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Adam W. Potter, Aitor Coca, Tyler Quinn, Tianzhou Wu, Kristine Isherwood, and Anita Perkins

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Biophysics and Biomedical Modeling Division
U.S. Army Research Institute of Environmental Medicine
Building 42 - 10 General Greene Avenue
Natick, MA 01760

8. PERFORMING ORGANIZATION REPORT NUMBER
T17-06

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Natick Soldier Research, Development, and Engineering Center (NSRDEC)
Natick, MA 01760

U.S. Army Medical Research and Materiel Command,
Fort Detrick, MD 21702

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
A tradespace assessment and planned optimization of clothing ensembles is underway to assess risks specific to operational regions. The intent of this report is to model one aspect of these regional-specific risks, by modeling thermal strain.

Twenty clothing ensembles were tested for thermal and evaporative resistances according to American Society of Testing and Materials (ASTM) standards using a sweating thermal manikin. Of the 20 ensembles tested, five subgroups were assessed based on similar types; 1) baseline ensembles, 2) undergarments vs. no undergarments, 3) Army Combat Shirt (ACS)-based, 4) Army Combat Uniform (ACU)-based, and 5) increased sizing. Thermal strain was modeled for each of the ensembles based on biophysical measurements within three environmental conditions (hot / dry, hot / humid, and temperate). Potential concepts for tradespace assessments related to clothing ensembles were discussed and outlined.

15. SUBJECT TERMS
thermal manikin; mathematical model; thermoregulation modeling; predictive modeling; physiological

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
Unclassified	Unclassified	Unclassified	Unclassified	25	Adam W Potter

19b. TELEPHONE NUMBER *(Include area code)*
508-233-4735

Reset

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ACKNOWLEDGMENTS

The authors would like to thank Mr. Julio Gonzalez (USARIEM) for reviewing the study design and providing technical expertise on the analysis.

EXECUTIVE SUMMARY

A tradespace assessment and planned optimization of clothing ensembles is underway to assess risks specific to operational regions. The intent of this report is to model one aspect of these regional-specific risks, by modeling thermal strain.

Twenty clothing ensembles were tested for thermal and evaporative resistances according to American Society of Testing and Materials (ASTM) standards using a sweating thermal manikin. Of the 20 ensembles tested, five subgroups were assessed based on similar types; 1) baseline ensembles, 2) undergarments vs. no undergarments, 3) Army Combat Shirt (ACS)-based, 4) Army Combat Uniform (ACU)-based, and 5) increased sizing. Thermal strain was modeled for each of the ensembles based on biophysical measurements within three environmental conditions (hot / dry, hot / humid, and temperate). Potential concepts for tradespace assessments related to clothing ensembles were discussed and outlined.

Noticeable differences in modeled thermal strain was observed across these ensembles; while Ensemble (E) 7 and E1 showed the least thermally burdensome and E19 and E18 the most thermally burdensome. For Group 1 (Baselines), E7 and E1 clearly outperform the other ensembles followed in order by E5, E3, and E6~~, and E4~~. In Group 2 (Undergarments vs. No Undergarments) ranked in from best to worst performing; E7, E1, E5, E2, E4, E6, E3 (Figure 5). Group 3 (ACS-Based) showed a clear distinction between performance of each of the configurations as (best to worst performing): E1, E16, E11, E9, E8, and E2 (Figure 6). Group 4 (ACU-Based) also showed distinct differences in performance as (best to worst performing): E7, E13, E20, E14, E5, E15, E3, E17, E6, E4, E12, and E10 (Figure 7). Group 5 (Increased Sizing) showed a relationship to increasing size and decreased performance; where the configurations with medium sized blouse and small sized trousers (E3, E4, and E5) performed best (E5 being slightly better), followed by the large blouse and medium trouser (E18), and lastly the extra-large blouse and large trouser (E19); while the ACS-Based ensembles (E8 and E9) performed better than the ACU-Based ensembles (Figure 8).

INTRODUCTION

For humans, clothing has long provided protection from environmental elements (e.g., heat, cold, etc.) or physical or biological hazards (e.g., rocks, thorns, etc.). Through changes in the human lifestyle and progression of civilizations, the aspects of protection have been less emphasized except for within harsher environments and activities. These include protection from the climatic elements (e.g., heat, cold, sun, rain, snow, etc.) but also include activities where hazards are expected such as during contact sporting events (e.g., football, hockey, etc.) or during military, law enforcement, or first responder operations (e.g., body armor, flame resistant clothing, etc.).

Clothing performance needs vary widely among users and use cases. Due to this specificity, clothing systems need to be optimized to meet defined demands. Clothing can be optimized to account for several variables but is not likely, given current technologies, to be optimized for full spectrum of environmental hazards. With this understanding in mind, the military has an invested interest in optimization of clothing and equipment based on specific threats to areas of operations or regions of the globe.

While there is an overarching effort to assess the tradespace and optimization of all of the threat elements; the intent of this report is to specifically model thermal strain. The goals of this report are: 1) outline biophysical measures from 20 clothing ensembles; 2) model thermal strain based on biophysical measurements while operating within various environmental conditions, and 3) outline potential concepts for a tradespace assessment related to clothing ensembles.

METHODS

Ensembles and biophysical measures

Biophysical properties (R_{ct} and R_{et}) were measured from 20 clothing ensembles (Table 1), many of which were designed to mitigate heat injury. Each clothing configuration was tested to American Society of Testing and Materials (ASTM) standards for "dry" thermal resistance (R_{ct}) (ASTM F1291-10) [1] and "wet" evaporative resistance (R_{et}) (ASTM F2370-10) [2], each at the prescribed wind velocity conditions of 0.4 m/s. These two measures represent the dry heat exchange (convection, conduction, and radiation) and wet heat exchange (evaporation). These measures of resistance were then converted into units of clo and i_m [3, 4], a ratio of the two for describing evaporative potential (i_m/clo) [5].

Table 1. Clothing configurations tested

Ensemble	*Group(s)*	**Description * ɫ**
E1	**1 2 3**	Briefs (20), Army Combat Shirt (7S), Army Combat Pants (16)
E2	**2 3**	Army Combat Shirt (7S), Army Combat Pants (16)
E3	**1 2 4 5**	T-Shirt (19), Briefs (20), ACU Coat (9M), ACU Pants (15S)
E4	**2 4 5**	Non-standard T-Shirt (22M), Briefs (20), ACU Coat (9M), ACU Trouser (15S)
E5	**1 2 4 5**	ACU Coat (9M), ACU Trouser (15S)
E6	**1 2 4**	T-Shirt (19), Briefs (20), ACU Simple Coat (8), ACU Simple Trouser (14)
E7	**1 2 4**	ACU Simple Coat (8), ACU Simple Trouser (14)
E8	**1 3 5**	Briefs (20), Army Combat Shirt (7S), ACU Trouser (15S)
E9	**3 5**	Briefs (20), Army Combat Shirt (7M), ACU Trouser (15S)
E10	**4**	T-Shirt (19), Briefs (20), Raglan w/ Gusset Coat (3), Double Gusset Trouser (10)
E11	**3**	Briefs (20), Wicking Torso Shirt (5), Army Combat Pants (16)
E12	**4**	T-Shirt (19), Briefs (20), Mesh Yoke Coat (2), Yoke Trouser (12)
E13	**4**	T-Shirt (19), Briefs (20), Cuff Design Coat-Closed (1), Scoop Trouser-Closed (13)
E14	**4**	T-Shirt (19), Briefs (20), Mesh Yoke Coat (2), Scoop Trousers-Open (13)
E15	**4**	T-Shirt (19), Briefs (20), Raglan w/ 2 Fabrics Coat (4), Double Gusset Trouser (10)
E16	**3**	Briefs (20), Cooling Torso Shirt (6), Army Combat Pants (16)
E17	**4**	T-Shirt (19), Briefs (20), Raglan w/ 2 Fabrics Coat (4), Double Gusset And Sleeve Touser (11)
E18	**5**	T-Shirt (19), Briefs (20), ACU Coat (9L), ACU Trouser (15M)
E19	**5**	T-Shirt (19), Briefs (20), ACU Coat (9XL), ACU Trouser (15L)
E20	**4**	T-Shirt (19), Briefs (20), Cuff Design Coat-Open (1), Scoop Trouser-Open (13)

* Item numbers (#) correspond to specific item selections (Appendix A)

ɫ All 20 ensembles include socks (18), Army Combat Boots (17) and a belt (21).

Comparison of ensemble types

Configurations were divided into groups based on type and then compared against each other for analysis. These groups consisted of 1) baseline ensembles, 2) undergarments vs. no undergarments, 3) ACS-based, 4) ACU-based, and 5) increased sizing (Table 2).

Table 2. Similar comparison configuration groups

Group	*Ensembles*	**Description**
1	**E1, 3, 5, 6, 7, 8**	**Baselines** Comparisons include the Army Combat Shirt (ACS) and Army Combat Pants (ACP)–Off the Shelf, Army Combat Uniform (ACU) - Off the Shelf, ACS and ACU Trousers, and simplified ACU Coat and Trouser without pockets, reinforcements, and padding
2	**E1, 2, 3, 4, 5, 6, 7**	**Undergarments vs. No Undergarments** Comparisons include configurations with and without undergarments
3	**E1, 2, 8, 9, 11, 16**	**ACS-Based** Configurations include tops that have the basic design of the AC Shirt.
4	**E3, 4, 5, 6, 7, 10, 12, 13, 14, 15, 17, 20**	**ACU-Based** Configurations include tops that have the basic design of the ACU Coat and ACU Trouser
5	**E3, 4, 5, 18, 19 (ACU) E8, 9 (ACS)**	**Increased Sizing** ACU configurations include ACU Coats size Medium (manikin best fit), Large, and Extra Large and ACU Trousers size Small (manikin best fit), Medium, and Large. ACS configurations include shirt size Small (manikin best fit) and Medium, using manikin best fit ACU Trousers.

Predictive modeling

Modeling thermoregulatory responses was conducted using the USARIEM Heat Strain Decision Aid (HSDA) [6-8]. Inputs into this model require calculations of wind effects typically obtained from multiple tests within controlled conditions at several wind velocities (e.g., more that the ASTM standard requirements). Recent work has successfully shown these effects from wind can be reasonably estimated from single measures of both R_{ct} and R_{et} at the standard wind speed [9-10].

The simulated human was a healthy male, weighing 70 kg, 172 cm tall, normally hydrated, and heat acclimatized. For modeling purposes, four elements were used to describe a climate condition; ambient temperature (T_a, °C), relative humidity (RH, %), mean radiant temperature (T_{mr}, °C), and wind velocity (V, m/s). Three simulated environmental conditions were used: hot-dry (desert) (T_a: 49°C; RH: 15%, T_{mr}: 69°C, V: 1 m/s), hot-wet (rainforest and jungle) (T_a: 35°C; RH: 75%, T_{mr}: 55°C, V: 1 m/s), and temperate (T_a: 25°C; RH: 50%, T_{mr}: 45°C, V: 1 m/s). Each simulated environment was assumed at sea level. For each simulation, work intensities simulating a walking speed

of 1.34 m/s (3 mph) were used. These metabolic costs of walking (M_w) were estimated using Eq. 1 [11] with an assumption that each clothing configuration added ~2.5 kg and walking was done on dirt roads (terrain feature $(\eta) = 1.1$) and an average of a 1% surface grade (G) Total M_w for each configuration was estimated to be 357W (Eq. 2).

$$M_W = 1.5 \cdot W + 2.0 \cdot (W + L) \cdot \left(\frac{L}{W}\right)^2 + \eta \cdot (W + L) \cdot (1.5 \cdot V^2 + 0.35 \cdot V \cdot G) \qquad \text{[Eq. 1]}$$

$$1.5 \cdot 70 + 2.0 \cdot (70 + 2.5) \cdot \left(\frac{2.5}{70}\right)^2 + 1.1 \cdot (70 + 2.5) \cdot (1.5 \cdot 1.34^2 + 0.35 \cdot 1.34 \cdot 1) = 357W \quad \text{[Eq. 2]}$$

RESULTS

Biophysical measurements

The measured total thermal (I_T, clo), evaporative (i_m) resistances, and evaporative potential (i_m/clo) are reported for each configuration in Table 3. Table 3 includes ASTM measured values at 0.4 m/s wind speed as well as estimated values of clo and i_m/clo at 1 m/s wind speed [10].

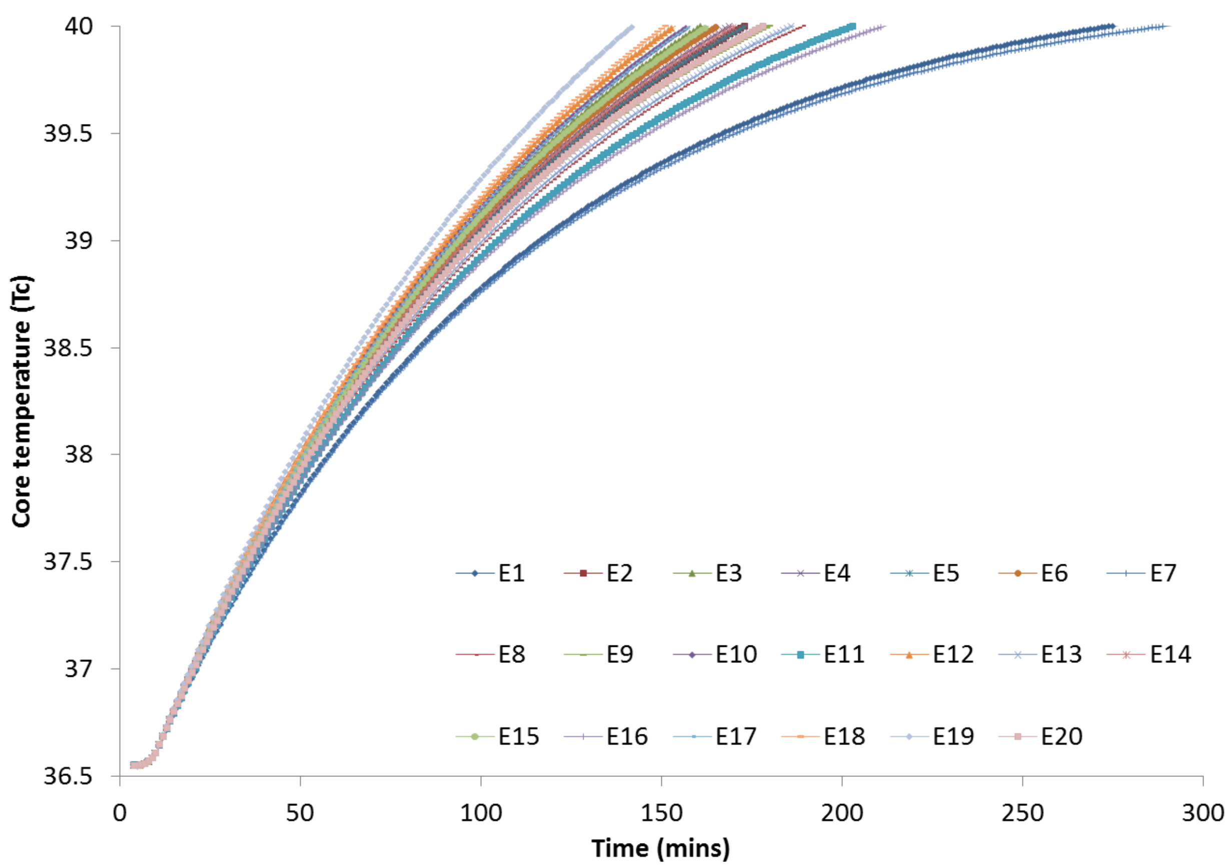
Table 3. Biophysical measures at 0.4 m/s (ASTM standard) and estimations at 1 m/s

Ensemble	*Measured*			*Estimated*			
	0.4 m/s clo	*0.4 m/s* i_m	*0.4 m/s* i_m/clo	*1 m/s* clo	*1 m/s* i_m/clo	*n.d.* *clo^g*	*n.d.* *i_m/clo^g*
1	1.075	0.381	0.354	0.882	0.483	-0.279	0.307
2	1.279	0.278	0.217	1.104	0.281	-0.224	0.258
3	1.348	0.359	0.266	1.111	0.353	-0.248	0.280
4	1.312	0.258	0.197	1.158	0.251	-0.204	0.240
5	1.258	0.226	0.180	1.111	0.225	-0.211	0.246
6	1.314	0.278	0.212	1.130	0.273	-0.222	0.256
7	1.113	0.369	0.331	0.878	0.450	-0.268	0.298
8	1.217	0.248	0.203	1.080	0.261	-0.214	0.249
9	1.247	0.331	0.266	1.034	0.353	-0.255	0.286
10	1.355	0.247	0.182	1.188	0.229	-0.202	0.239
11	1.172	0.276	0.235	1.021	0.308	-0.232	0.265
12	1.367	0.323	0.236	1.135	0.309	-0.241	0.274
13	1.251	0.289	0.231	1.092	0.302	-0.220	0.255
14	1.288	0.314	0.244	1.080	0.321	-0.242	0.275
15	1.322	0.317	0.240	1.105	0.314	-0.241	0.274
16	1.148	0.333	0.290	0.956	0.388	-0.263	0.293
17	1.359	0.371	0.273	1.106	0.363	-0.255	0.287
18	1.380	0.325	0.236	1.143	0.308	-0.241	0.274
19	1.434	0.316	0.220	1.193	0.286	-0.232	0.266
20	1.258	0.299	0.238	1.069	0.311	-0.237	0.270

Predictive modeling

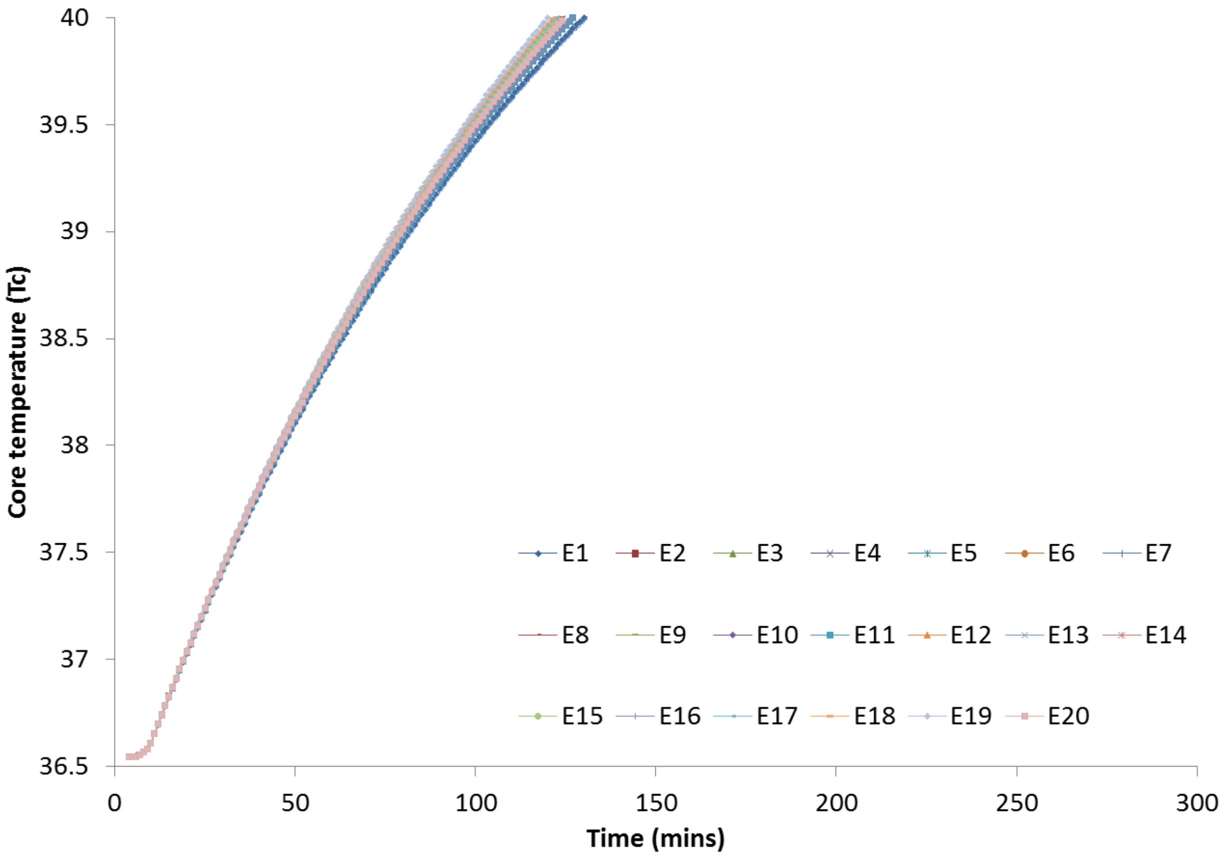
Thermoregulatory responses, specifically as core body temperature (T_c, °C) rise for each configuration, was modeled for each ensemble in three different environments; hot-dry (Figure 1), hot-wet (Figure 2), and temperate (Figure 3). For easier comparison, Table 4 ranks each configuration and describes the time point at which each reaches a predicted T_c of 38.5 and 39.5°C. Instances of uncompensable heat stress, where the evaporative cooling demands exceed the possible environmental conditions poses higher risk of injury. Studies have shown that during activities or environments where uncompensable heat stress is imposed there is a 50% likelihood of injury at or around 38.5°C (e.g., hot/humid environment, or in personal protective equipment) and in compensable conditions (e.g., hot/dry, temperate) at or around 39.5°C [12].

Figure 1. Modeled core temperature (T_c) rise for walking 1.34 m/s (3 mph; 357W) in hot-dry conditions (T_a: 49°C, RH: 15%, T_{mr}: 69°C, V: 1 m/s) for 20 clothing configurations



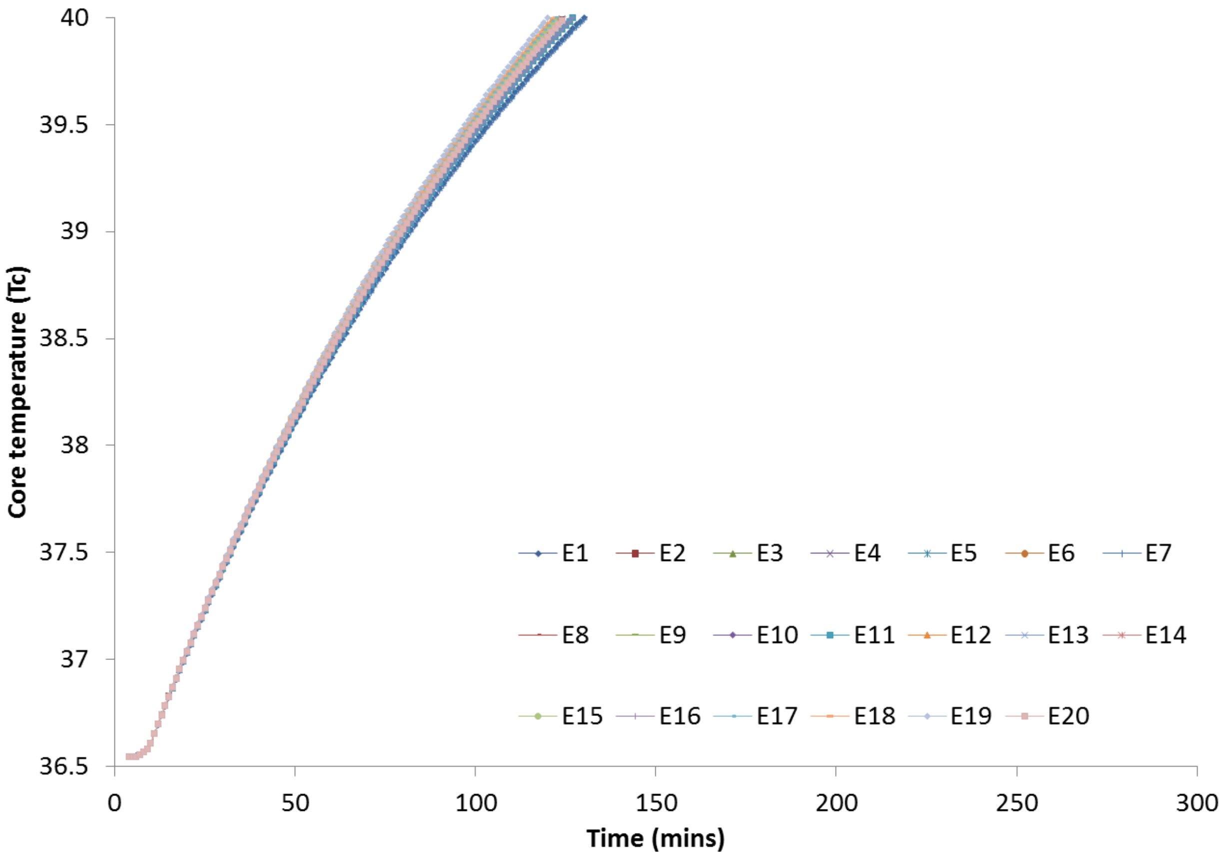
From the modeled responses to hot-dry conditions (Figure 1, Table 4), the general trend can be observed across all ensembles. However, there are noticeable differences across these ensembles with E7 and E1 being the least thermally burdensome and E19 and E18 being the most thermally burdensome.

Figure 2. Modeled core temperature (T_c) rise for walking 1.34 m/s (3 mph; 357W) in hot-wet conditions (T_a: 35°C, RH: 75%, T_{mr}: 55°C, V: 1 m/s) for 20 clothing configurations



The modeled thermal responses to hot-wet conditions (Figure 2, Table 4) show little differences across all ensembles. While relatively negligible though similar to the hot-dry conditions, E7 and E1 performed better overall and E12, E18, and E19 performed more poorly.

Figure 3. Modeled core temperature (T_c) rise for walking 1.34 m/s (3 mph; 357W) in temperate conditions (T_a: 25°C, RH: 50%, T_{mr}: 45°C, V: 1 m/s) for 20 clothing configurations



Modeled thermal responses to temperate conditions (Figure 3, Table 4) show similar trends in performance to both the hot-dry and the hot-wet conditions; where E7 and E1 performed best, followed closely by E16, while E19, E10, and E18 performed more poorly. All of the ensembles when modeled over the 5 hour period showed to be able to remain under the critical T_c of 39.5°C; while both E1 and E7 modeled to capable of remaining under both of the critical T_c limits of 38.5 and 39.5°C

Table 4. Time point to reach critical core body temperatures (T_c) and rank order by physiological responses to each environmental condition

Ensemble	Hot-Dry			Hot-Wet			Temperate		
	Time (38.5°C)	Time (39.5°C)	Rank	Time (38.5°C)	Time (39.5°C)	Rank	Time (38.5°C)	Time (39.5°C)	Rank
1	83	167	2	63	104	2	>300	>300	1*
2	73	129	9*	62	100	5*	168	>300	8
3	70	122	13	61	99	6*	160	>300	11
4	72	127	10*	62	100	5*	156	>300	14
5	73	129	9*	62	100	5*	166	>300	9
6	71	125	11	62	100	5*	158	>300	13
7	84	171	1	64	104	1	>300	>300	1*
8	75	137	5	62	101	4*	183	>300	5
9	74	132	7	62	100	5*	192	>300	4
10	70	121	14*	61	99	6*	144	>300	16
11	77	143	4	63	102	3*	211	>300	3
12	69	118	15	61	98	7*	150	>300	14
13	75	135	6	62	101	4*	180	>300	6*
14	72	127	10*	62	100	5*	172	>300	7
15	71	123	12	61	99	6*	162	>300	10
16	78	147	3	63	102	3*	254	>300	2
17	70	121	14*	61	99	6*	159	>300	12
18	68	117	16	61	98	7*	147	>300	15
19	66	112	17	61	97	8	134	>300	17
20	73	131	8	62	100	5*	180	>300	6

*Tied with one or more clothing configuration

Comparison of ensemble types

The grouped comparisons of the various clothing configurations were based on the estimated times to reach critical T_c levels of 38.5°C. For Group 1 (Baselines), E7 and E1 clearly outperform the other ensembles followed in order by E5, E3, E6, and E4 (Figure 4); while for Group 2 (Undergarments vs. No Undergarments) similar comparisons as Group 1, where ranked in from best to worst performing; E7, E1, E5, E2, E4, E6, E3 (Figure 5). Group 3 (ACS-Based) showed a clear distinction between performance of each of the configurations as (best to worst performing): E1, E16, E11, E9, E8, and E2 (Figure 6). Group 4 (ACU-Based) also showed distinct differences in performance as (best to worst performing): E7, E13, E20, E14, E5, E15, E3, E17, E6, E4, E12, and E10 (Figure 7). Group 5 (Increased Sizing) showed a relationship to increasing size and decreased performance; where the configurations with medium sized blouse and small sized trousers (E3, E4, and E5) performed best (E5 being slightly better), followed by the large blouse and medium trouser (E18), and lastly the extra-large blouse and large trouser (E19); while the ACS-Based ensembles (E8 and E9) performed better than the ACU-Based ensembles (Figure 8).

Figure 4. Comparison of Baseline Configurations (Group 1) predicted times to reach critical core body temperatures (T_c) of 38.5°C in three environmental conditions

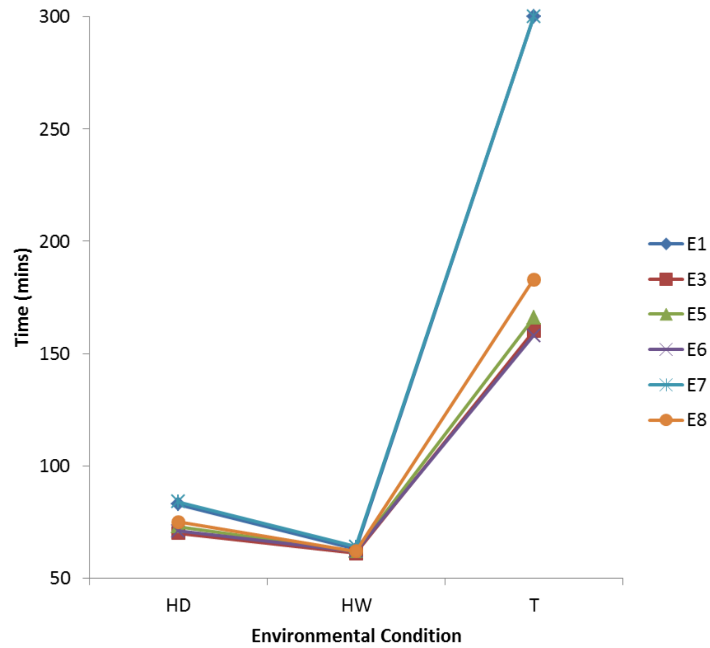
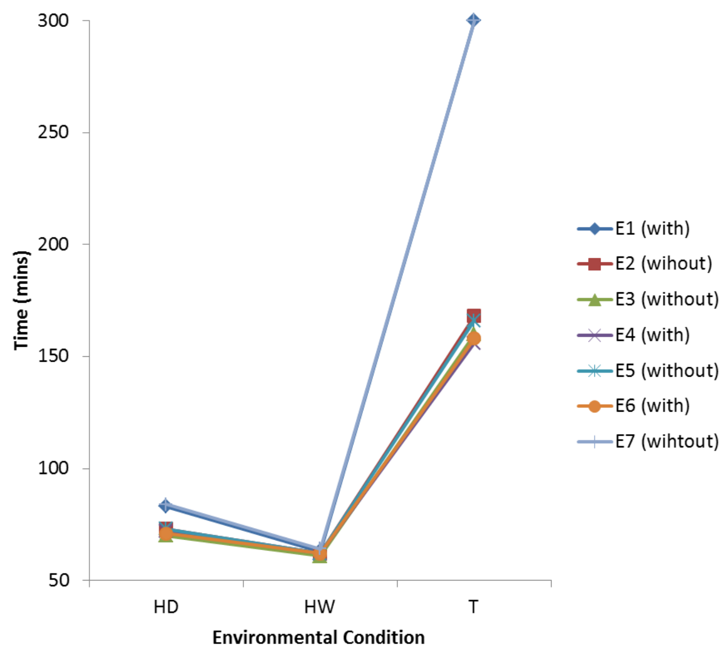


Figure 5. Comparison of Undergarment vs. No Undergarment Configurations (Group 2) predicted times to reach critical core body temperatures (T_c) of 38.5°C in three environmental conditions



*Hot-Dry (HD); Hot-Wet (HW); Temperate (T)

Figure 6. Comparison of ACS-Based Configurations (Group 3) predicted times to reach critical core body temperatures (T_c) of 38.5°C in three environmental conditions

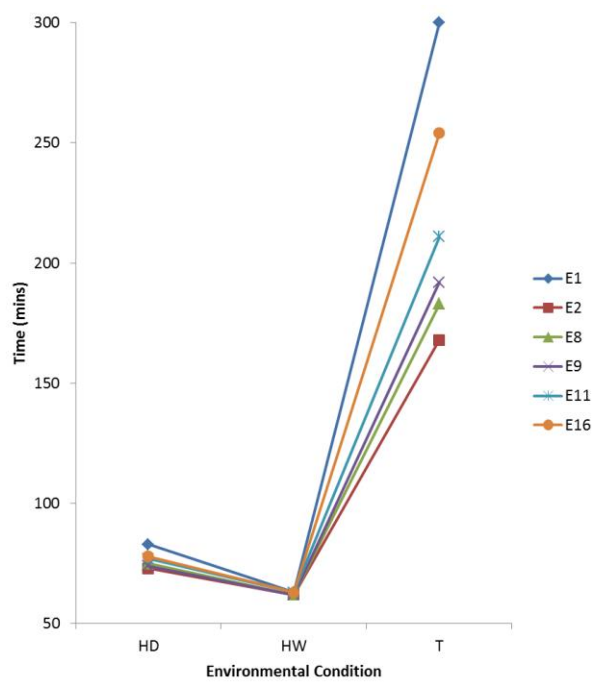
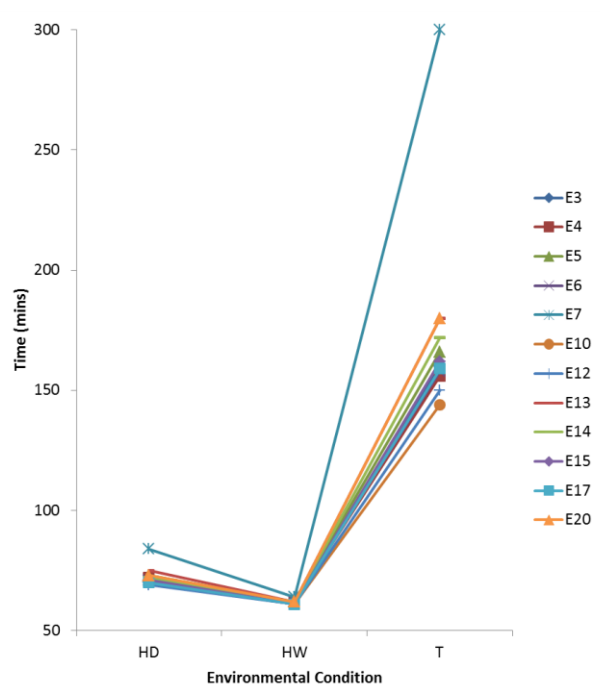
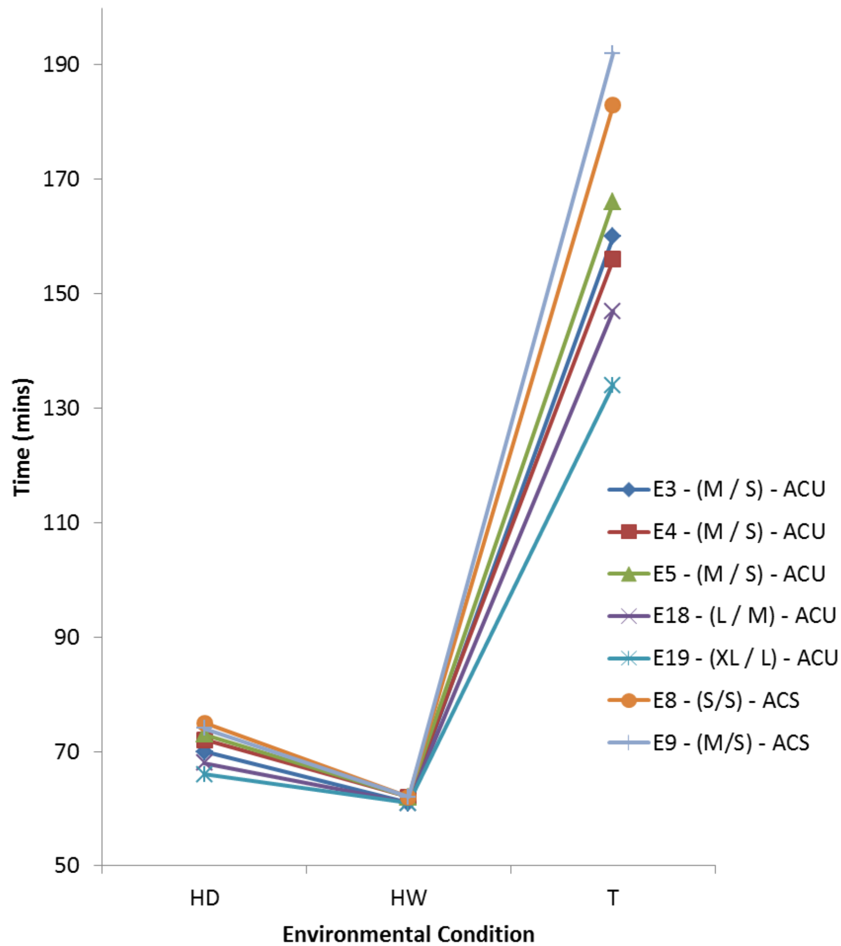


Figure 7. Comparison of ACU-Based Configurations (Group 4) predicted times to reach critical core body temperatures (T_c) of 38.5°C in three environmental conditions



*Hot-Dry (HD); Hot-Wet (HW); Temperate (T)

Figure 8. Comparison of Increased Sizing Configurations (Group 5) predicted times to reach critical core body temperatures (T_c) of 38.5°C in three environmental conditions



*Hot-Dry (HD); Hot-Wet (HW); Temperate (T)

DISCUSSION

Algorithms and more complex mathematical models offer useful ways to organize scientific knowledge and to predict human performance. However, as part of a model-test-model process [13], it is important that we continue researching specific populations and scenarios to ensure optimal estimations are developed. For example, modeling the differences in endurance time can be complicated by fitness levels of individuals and clothing worn, as core body temperatures in excess of 40°C have been seen in distance runners with no observed injuries [14]. As noted earlier, this type of compensable heat strain differs greatly from limits in compensable (~39.5°C) and uncompensable conditions (~38.5°C) described by Sawka et al., [12]. Furthermore, the various equations should be continuously reviewed and revised to ensure that adequate

variables are used for specific populations and their respective demands. For example, estimations of metabolic cost for activities for athletes are based on significantly different variables compared to military activities (e.g., movement on flat surface with additional loads versus mixed terrain unloaded) [15-16].

For cost effectiveness, a continued approach to simulations and modeling methods should be sought rather than moving directly into human research and user field evaluations. However, it should also be noted that continued modeling, analysis, and algorithm development is essential to improving the accuracy and effectiveness of simulations. For example, human research studies using body worn sensor systems to collect relevant physiological data can be extremely helpful in validating and improving existing models [17-18]. Furthermore, from these field and laboratory studies, advanced modeling techniques can be developed that can be broadly applied to both real-time [19-20] and stationary assessments [21-22]. Customized variants empirically derived or rational modeling approaches can be used to determine safe stay times in built spaces (e.g., aircraft, vehicles, buildings) for a variety of applications. These modeling and simulation approaches can be applied to complex environments such as submarines [23] or even modified for other species such as canines in enclosures [24].

Additional considerations of the ergonomic and thermal comfort impacts of various ensembles also play significant a significant part in overall performance. Work has shown elements of personal protective ensembles can impact physiological outcomes [25-26], thermoregulation [27], and possible physical performance [28]. While this paper does not address thermal comfort directly, there has been a great deal of research invested into this area from a clothing aspect [29-30], enclosed spaces aspect [31], as well as from an open spaces perspective [32]. Work has gone specifically into addressing thermal comfort from textile properties in military ensembles [33-34]. Recent work has also studied the impact that ensemble spectrophotometric values play in modeled thermal comfort [35].

Tradespace analysis

For simplicity, the tradespace analysis of clothing and human performance can encompass seven main elements; weight, ballistic protection, thermal strain, cold protection, environmental hazards, fire protection, and mobility.

A theoretical representation of this tradespace can be seen in Figure 9. Figure 10 represents how tailoring of these elements can be done based on needs or location, where the optimal balance is centered among these elements (A) and imbalances would result in over or under compensation of elements (B-H).

Figure 9. Simplified tradespace for clothing ensembles

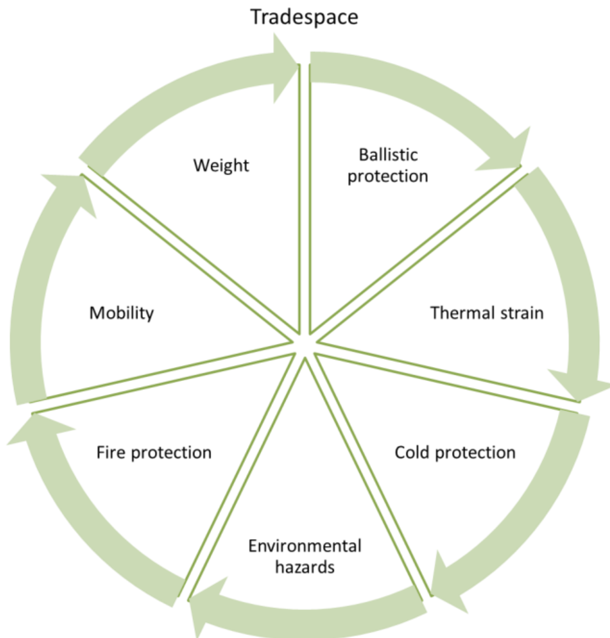
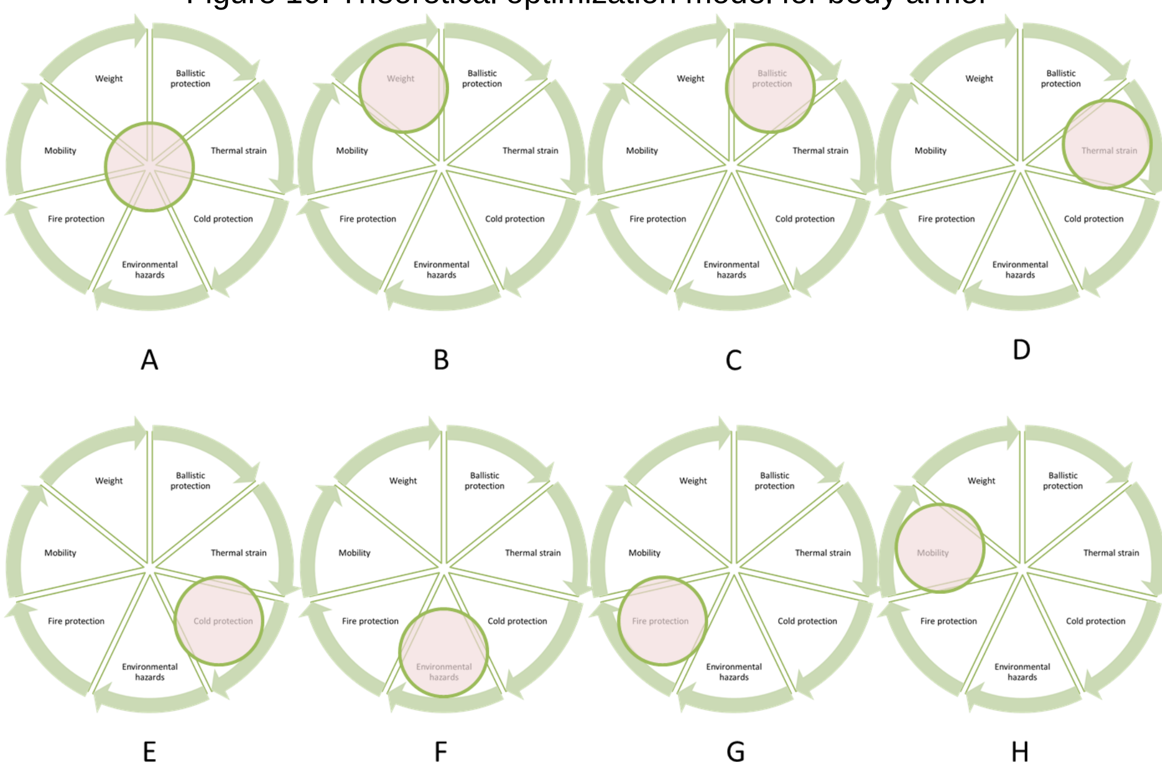


Figure 10. Theoretical optimization model for body armor



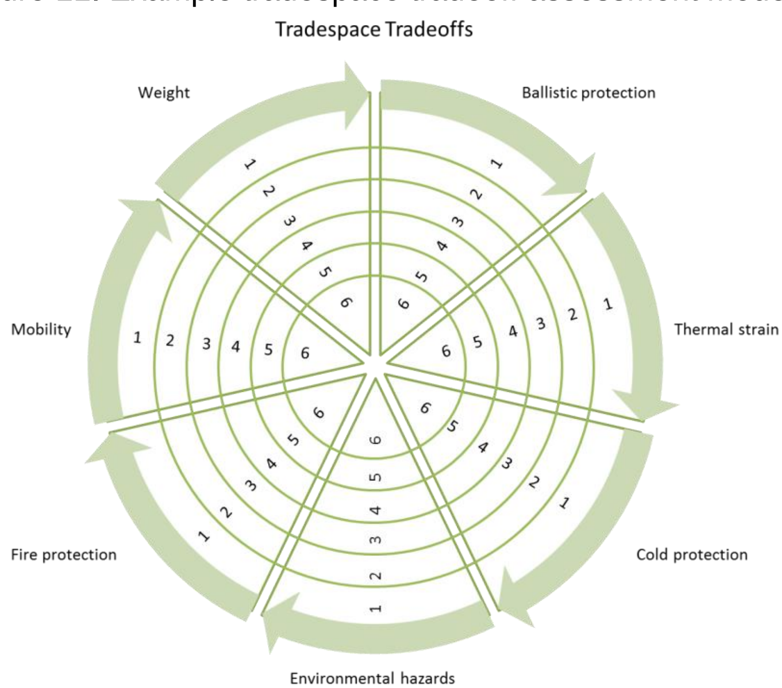
A = Optimal balance
B = Weight balanced
C = Ballistic protection balanced
D = Thermal strain balanced
E = Cold protection balance
F = Environmental hazards balanced
G = Fire protection balanced
H = Mobility balanced

These elements could be expanded or simplified based on anticipated threats. For example, ideally for dismounted military the emphasis would be on maximal ballistic protection and mobility, with minimal weight and thermal burden. However, typically there is an inverse relationship between 1) ballistic protection and thermal burden and 2) weight and mobility [36-37]. Added layers of body armor typically translate to increases in thermal insulation and reduced ability for evaporation, thus increased thermal burden; while increased weight typically decreases range of motion and increases metabolic demands, thereby decreasing mobility. Optimal tradeoff of these elements should be tailored to the anticipated physical demands of the mission.

The tradeoff analysis can be done on a larger scale for enduring issues and configuration comparisons by standardizing metrics of performance. For example, assigning numeric value to each of the sections in the tradespace representing quality evaluations for each component (e.g., Likert scale data [38]) enables uniform comparisons. Using this approach, systematic evaluations can be done specific to each element in the tradespace and can then be translated into the simplified optimization model for comparison.

It could be simpler for each element to be the same scale; however not critical, assuming the weights are proportional to the area within each element (i.e., 1-3 would be three proportional sections of the pie, as would 1-7). Using this method allows for multiple evaluators and performing entities, assuming there are quantifiable standards for how evaluations occur (e.g., weight of ≤ 10kg is a rating of 5, 11-15kg is a 4, etc). Given there is not a completely equal inverse relationship between elements, this method allows for more realistic tradespace assessments (i.e., a perfect circle is not always reality). An example of how this can be performed can be seen in Figure 11.

Figure 11. Example tradespace tradeoff assessment model



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APPENDIX A

Component items, number designators, descriptions, and associated ensembles configurations

Item#	Description	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20
1	Cuff Design Blouse-Open													X							X
2	Mesh Yoke Blouse												X		X						
3	Raglan w/Gusset Blouse										X										
4	Raglan w/2 Fabrics Blouse															X		X			
5	Wicking Torso Shirt											X									
6	Cooling Torso Shirt																X				
7M	Army Combat Shirt, Size Medium									X											
7S	Army Combat Shirt, Size Small	X	X						X												
8	ACU Blouse-Simple						X	X													
9L	ACU Blouse, Size Large																		X		
9M	ACU Blouse, Size Medium			X	X	X															
9XL	ACU Blouse, Size Extra Large																			X	
10	Double Gusset Trouser										X					X					
11	Double Gusset & Sleeve Trouser																	X			
12	Yoke Trouser												X								
13	Scoop Trouser													X	X						X
14	ACU Trouser-Simple						X	X													
15L	ACU Trouser, Size: Large																			X	
15M	ACU Trouser, Size: Medium																		X		
15S	ACU Trouser, Size: Small			X	X	X			X	X											
16	Army Combat Pants	X	X									X					X				
17	Army Combat Boots	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
18	Socks	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
19	Standard T-Shirt			X			X				X		X	X	X	X		X	X	X	X
20	Briefs	X		X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X
21	Belt	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
22M	Cocona T-Shirt, Size Medium				X																